LATTICE TOUCH-SENSING SYSTEM

FIELD OF INVENTION

[0001] The present invention relates to a lattice touch-sensing system. More particularly, the present invention relates to a touch-sensing system with a touch-sensitive surface that includes sensor bars laid out in a lattice.

BACKGROUND OF THE INVENTION

[0002] As computers and other electronic devices become more ubiquitous, touch-sensing systems are becoming more prevalent as a means for inputting data. For example, touch-sensing systems may now be found in workshops, warehouses, manufacturing facilities, restaurants, on hand-held personal digital assistants, automatic teller machines, casino game-machines, and the like.

[0003] Capacitive touch sensing is one of the most widely used techniques in touch screen industries. Capacitive touch sensors are mainly divided in two groups, namely, the continuous capacitive sensors, and discontinuous (patterned) capacitive sensors. In a continuous capacitive sensor, the sensor consists of a sheet of conducting thin film that is excited from four corners. The signals induced by a touch are transmitted from the corners to a controller, where they are decoded and translated to coordinates. In a typical patterned capacitive touch screen the sensor consists of a series of parallel conductive bars that are driven from both ends with an excitation signal from the controller. The signals induced by a touch are transmitted to the controller with the same lead lines that excite the sensor bars. These signals are then decoded in the controller and the touch coordinates are reported to a computer. For examples of this type of sensor refer to U.S. Pat. No. 5,650,597, and U.S. patent application Ser. No. 10/176,564.

[0004] In patterned capacitive screens different methods are used to calculate the touch coordinates. For example, in capacitive screens using near field imaging (NFI) the coordinate along the parallel bars, the X-axis, is determined by ratio of the voltage drops on left and right of the touch. The coordinate in the direction perpendicular to the bars, the Y-axis, is determined by finding the location of the touched bar combined by interpolation methods.

[0005] Touch sensors utilizing more than one patterned sensing layer can be used to determine the coordinates of a touch with high accuracy in both directions, provided that the sensing layers have the proper pattern geometry. Examples of multi-layered capacitive touch sensors are U.S. Pat. No. 4,686,332, and U.S. Pat. No. 6,137,427. The challenge of capacitively coupling to more than one sensing layer has forced the designers either to use very narrow conducting bars, or to use bars with vastly different widths on the two layers. The former design suffers from a very low signal level, and the latter design has significant error due to sparse distribution of the bars.

SUMMARY OF THE INVENTION

[0006] This invention is directed to a touch-sensing system for detecting a position of a touch on a touch-sensitive surface. The touch-sensing system comprises at least two layers of unidirectional capacitive sensor bars where each sensor bar is electrically connected at one or both ends to a lead line. According to one example, the other end of the sensor bar may be left open, which enables the area on that side of the touch sensor to be as small as possible. In another example, one or more layers may be connected at both ends so that weaker touches or multiple touches may be sensed. The sensor bars of the layers are disposed in a lattice configuration such that the sensor bars of one layer are disposed in a different direction from the sensor bars of the other layer. A touch on the touch-sensing system is located in one direction by signals from one layer of sensor bars, and in another direction by signals from the other layer of sensor bars.

[0007] In one aspect of the invention, the lattice touch-sensing system includes a surface and a lattice touch-sensing circuit. The sensing circuit comprises two sets of parallel and unidirectional capacitive sensor bars where the sensor bars of the first set are not parallel to the sensor bars of the second set. Each sensor bar of a given set of sensor bars is electrically connected to a lead line of a corresponding set of lead lines.

[0008] In another aspect of the invention, the lattice touch-sensing system includes a surface, a lattice touch-sensing circuit with two sets of parallel and unidirectional capacitive sensor bars and two corresponding sets of lead lines, and a control circuit. The control circuit provides an excitation signal to both set of sensor bars through the corresponding set of lead lines, receives sensing signals produced when a touch on the surface occurs, and determines the position of the touch from the sensing signals.

[0009] In yet another aspect of the invention, the lattice touch-sensing system includes a touch pane, two sensor planes separated by a sheet of dielectric material, and a control circuit. Each of the two sensor planes includes parallel and unidirectional capacitive sensor bars, which are electrically connected to corresponding lead lines. The lead lines are electrically connected to the control circuit, which provides an excitation signal to the sensor bars through the lead lines, receives sensing signals produced when a touch on the surface occurs, and determines a position of the touch from the sensing signals.

[0010] In still another aspect of the invention, the lattice touch-sensing system includes a touch surface and a lattice touch-sensing circuit. The sensing circuit includes two layers of unidirectional capacitive sensor bars where the sensor bars of the first layer are not parallel to the sensor bars of the second layer. More than one sensor bar of a given layer of the touch-sensing circuit is electrically connected to the same lead line of a corresponding set of lead lines. A signal-processing scheme is then used to distinguish which of the sensor bars experience the touch.

[0011] In still another aspect of the invention, the lattice touch-sensing system includes a touch surface and a lattice touch-sensing circuit. The sensing circuit includes two layers of unidirectional capacitive sensor bars where the sensor bars of the first layer are not parallel to the sensor bars of the second layer. Each sensor bar of one or both layers of the touch-sensing circuit is electrically connected at both ends to a lead line, wherein the resultant touch sensing system has improved multiple-touch recognition and/or rejection characteristics over a similar single-ended system.